NOVEMBER 1957

STATION PAPER NO. 54



SILVICAL *Characteristics* OF . . .

# AMERICAN ELM

(*Ulmus americana*)

Paul C. Guilkey

LAKE STATES FOREST EXPERIMENT STATION
M. B. Dickerman, Director

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

## THE SILVICAL REPORTS

During 1907 and the following several years the U. S. Forest Service issued a series of silvical leaflets which covered the broad characteristics of a considerable number of major timber species. Since then much new knowledge has accumulated--some of it published in a variety of sources. There is also a considerable store of unpublished silvical information in the files of the forest experiment stations, the forest schools, and some other agencies. To compile this information systematically and make it available to foresters generally, the Lake States Forest Experiment Station is preparing reports on 15 individual species. Similar reports are being prepared by the other Federal forest experiment stations. When completed, these individual species reports will provide the basis for a comprehensive manual of silvics for the important trees of the United States, to be published by the U. S. Forest Service.

This report is one of the series being prepared by the Lake States Station. A preliminary draft was reviewed by several members of our own Station staff and by a number of well qualified staff members of other forest experiment stations, colleges, and universities; Federal, State, and Provincial forestry organizations; and forest industry. Their comments helped the author to make this report more complete, more accurate, and more up to date. Especially helpful reviews were submitted by Dr. D. B. Lawrence, University of Minnesota; R. U. Swingle, Agricultural Research Service; E. J. Schreiner and J. W. Wright, Northeastern Forest Experiment Station; and R. R. Whitten, Central States Forest Experiment Station.

Every effort has been made to ensure the accuracy and completeness of the information concerning the silvical characteristics of each species consistent with a brief treatment of the subject. We shall appreciate it, however, if any errors or omissions of important information are brought to our attention.

M. B. Dickerman

M. B. Dickerman, Director

Cover: Typical forest-grown American elms in southern Michigan. Recently these trees were freed by cutting. Drawing represents leaves and seed.

CONTENTS

# SILVICAL CHARACTERISTICS OF AMERICAN ELM
## (Ulmus americana L.)

by

Paul C. Guilkey
Lake States Forest Experiment Station[1/]

American elm is the largest and most important of the six elms native to eastern North America. Two varieties are recognized, the typical variety Ulmus americana var. americana and Ulmus americana var. floridana (24).[2/] Florida elm, accepted as a species by some authors and regarded as a synonym of U. americana in the 1927 Checklist (39), was placed as a variety in the 1953 Checklist (24). Common names for the typical variety include: American elm, soft elm, water elm, white elm, grey elm, and swamp elm.

## DISTRIBUTION

The typical variety (U. americana var. americana) is found throughout eastern North America (16, 17, 30, 43) (fig. 1). Its botanical range is from southern Newfoundland westward through southern Quebec and Ontario, northwest through Manitoba into eastern Saskatchewan, then south on the upper flood plains and protected slopes in the Dakotas, in the canyons and flood plains of northern and eastern Kansas, except for the grasslands of the Flint Hills section, and in eastern Oklahoma and central Texas on upland sites and in ravines and pockets along the Cimarron and Canadian Rivers (1). American elm is common along the gulf coast east into central Florida and in all of the Eastern States.

Florida elm (U. americana var. floridana) is restricted to the coastal plains from eastern North Carolina to central Florida (24).

The northern boundary of the commercial range (fig. 1) of American elm extends from Maine, west through southern Ontario and the Lake States; the southern boundary runs southwest from Pennsylvania to southern Alabama and Louisiana (8).[3/]

---

1/ Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minn., in cooperation with the University of Minnesota.

2/ Underlined numbers in parentheses refer to literature cited on page 15.

3/ Commercial range is defined as that portion of the botanical range in which the species attains commercial size and is a major or important component of the type.

AMERICAN ELM (Ulmus americana)

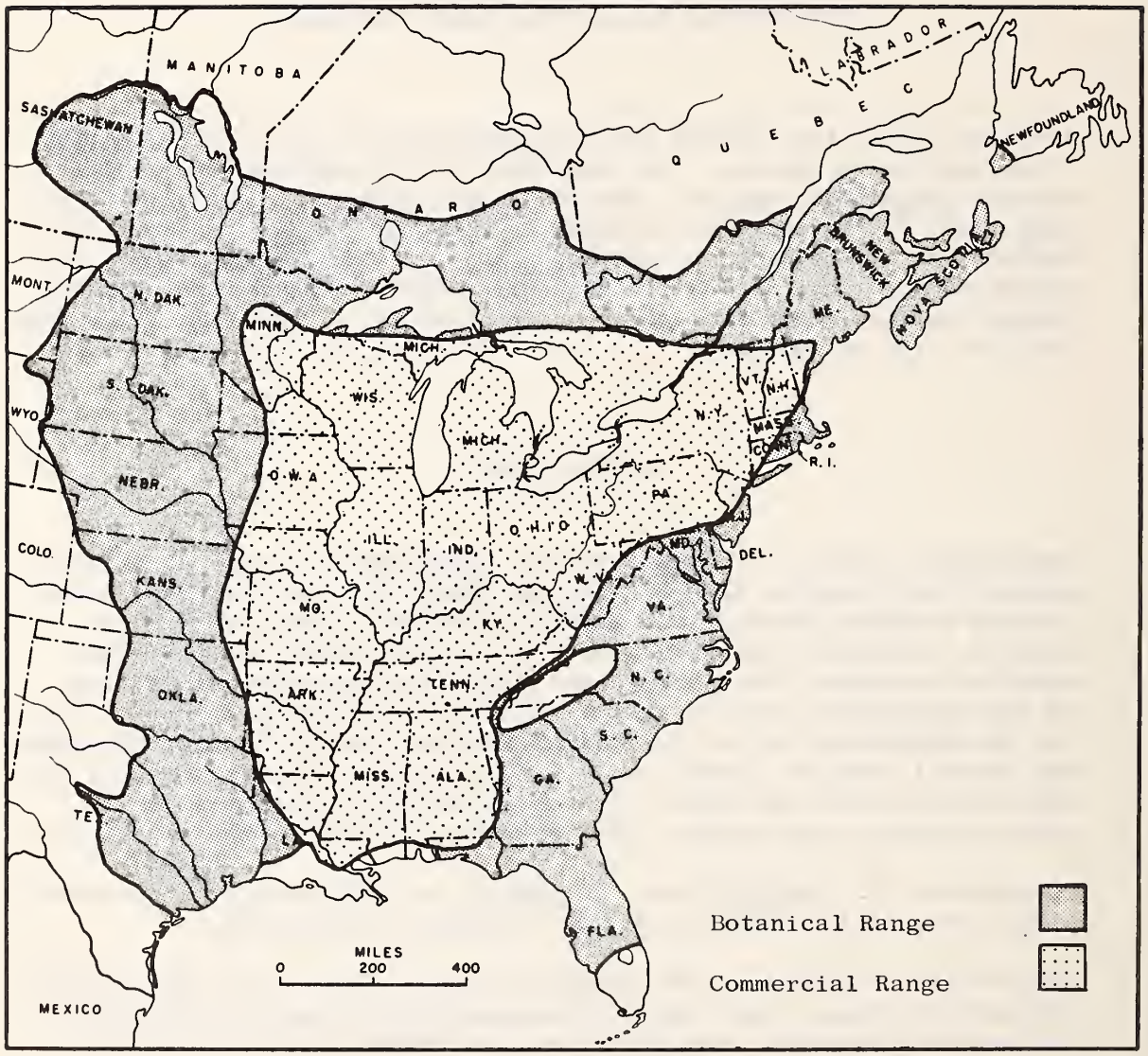


Figure 1.--Botanical and commercial range of American elm.

## HABITAT CONDITIONS

### Climatic Factors

Average climatological figures for the botanical range are almost meaningless as this species is found in nearly all of Thornthwaite's Climatic Provinces and Mulford's Plant Growth Regions east of the 100th meridian (46). The average January temperatures range from 0° F. and below in Canada to 60° in central Florida. Average July temperatures range from about 60° in Manitoba to 80° in the southern States. Average annual maximum temperatures range from 90° to 100° over most of the range and to 105° in the west; the highest temperatures on record are about 10° higher. Average annual minimum temperatures range from about -40° to 30°, and the lowest temperatures on record are from 10° to 20° lower (42).

Precipitation is usually adequate for growth although severe droughts occur periodically in the west and are not unknown in the east. Average annual precipitation varies from 15 inches in North Dakota and Manitoba to about 60 inches in the Gulf States. Over most of the commercial range the annual precipitation ranges from 30 to 55 inches. The average warm season (April through September) precipitation varies from 10 to 15 inches in the north and west to 30 to 35 inches in the southeast.

The average annual snowfall varies from none in Florida to 150 inches in upper New York. Along the northern edge of the botanical range, average annual snowfall varies from about 30 inches in the west to around 100 inches in the east. Over much of the commercial range the average annual snowfall varies from about 2 to 60 inches (42).

The average date of the last killing frost varies from June 10 in the northeast to about February 18 in Florida. The average date of the first killing frost varies from about September 10 in the north to about December 20 in the south. The frost-free period averages from about 80 to 100 days in the north to about 280 to 320 days in the south. (42)

The climate within the botanical range of American elm varies from humid in the southeast to semi-arid in the northwest. The average number of cloudy days per year varies from 100 days in the south and west to 180 days in the north. The percentage of summer sunshine is highest in the west with 70 to 80 percent of possible sunshine, moderate in the Lake States and the southeast with 60 to 70 percent, and lowest in New England and Canada with less than 60 percent. (42)

## Edaphic Factors

American elm is common on wet flats and bottomlands but is not restricted to these moist sites. It can be found on nearly all of the great soil groups occurring within its botanical range. These soil groups range from the podzols of the Lake States, New England, and Canada through the brown podzolic soils of New England, the gray brown podzolic soils of the Lake and Central States, the prairie soils of the Midwest, and the red and yellow podzolic soils of the South (41, 43, 46, 48). On the intrazonal soils, elm is found on the planosols of the Midwest, and the ground water podzols and half bog soils of the Lake States and southern Atlantic Coast. Of the azonal soils, elm is common only on the alluvial soils.

American elm grows on all textures of soils, ranging from coarse sands to clays, but reaches its best development on rich well-drained loams. The soil moisture regime may influence the growth of elm more than does soil texture alone (47). Elm grows poorly in droughty sands and often also in soils where the summer water table is at or near the surface. In Michigan, the effect of the summer water table is modified somewhat by soil texture.[4/] On loam and clay soils the growth was good when the summer water table dropped to 8 to 10 feet below the surface, medium with a summer water table at 4 to 8 feet, and poor when the topsoil was wet throughout the year. On sandy soils underlain by clay, growth was medium to good where the summer water table was 2 or more feet below the soil surface. The organic soils were usually poor sites but those with a summer water table at least 2 feet below the surface were classed as medium sites for elm.

In the South, elm is common on clay and silty-clay loams on first bottoms and terraces; growth is medium on the wetter sites and good on well-drained flats in first bottoms (32). In the arid western end of the range, elm is usually confined to the silt or clay loams in river bottoms or terraces. However, where shelterbelts have been planted on the uplands, survival is generally best on the sandy soils where the moisture is more evenly distributed to greater depths than in the fine textured soils (19).

The humus layer under stands containing American elm is generally a mull. The range of soil acidity varies from very strongly or strongly acid on some of the swamp margin sites in the Lake States with a pH as low as 4.8 to 5.5, to the mildly alkaline prairie soils with a pH of 7.4 to 8.0 on the western edge of the range (19, 48). The range of soil reaction considered to be suitable for American elm is from pH 5.5 to 8.0 (48).

---

4/ Boughner, W. S., et al. 1955. The lowland hardwood type in southern Michigan. Lake States Forest Expt. Sta., unpublished ms.

The foliage of American elm usually contains from 1 to 2 percent calcium. Accordingly elm is considered a "soil-improving" tree species (25).

## Physiographic Factors

American elm is most common on wet flats and bottomlands throughout its range but is not restricted to these sites. In the southern bottomland region, it occurs widely in first bottoms and terraces, especially on first bottom flats, but not in deep swamps (32). At higher elevations in the Appalachians it is often limited to the vicinity of larger streams and rarely occurs at elevations above 2,000 feet. However, in West Virginia it does occur in high coves at elevations of 2,500 feet.[5/] In the Lake and Central States, it is found on plains and morainal hills as well as in the bottomlands and swamp margins. Along the northwestern edge of the range, it is usually restricted to valley bottoms along water courses except where it has been planted on the uplands.

## Biotic Factors

Throughout its range, American elm seldom grows in pure stands and is usually found in mixtures with other species. It is an integral member of four cover types recognized by the Society of American Foresters (38). The black ash (Fraxinus nigra)-American elm-red maple (Acer rubrum) type (no. 39) occurs throughout the northern forest and into the boreal forest in Canada, and throughout the Lake States and into the northern edge of the central forest. The silver maple (A. saccharinum)-American elm type (no. 62) is common throughout the central forest and extends into Canada. The sugarberry (Celtis laevigata)-American elm-green ash (Fraxinus pennsylvanica) type (no. 93) and the sycamore (Platanus occidentalis)-pecan (Carya illinoensis)-American elm type (no. 94) are found throughout the southern forest within the flood plains of the major rivers. In addition to these four cover types, American elm is mentioned in cover types 16, 24, 25, 26, 29, 42, 49, 52, 54, 56, 60, 63, 82, 85, 91, 92, 95, 96, 99, 101, 102, and 104. A complete list of all the tree species associated with American elm in these cover types would include most of the species common to eastern North America.

---

5/ Unpublished information, Northeastern Forest Experiment Station.

In the black ash-American elm-red maple type the most common associates, other than the type species, are: In the Lake States and Canada, balsam poplar (Populus balsamifera), balsam fir (Abies balsamea), and yellow birch (Betula alleghaniensis); in Ohio and Indiana, silver maple, swamp white oak (Quercus bicolor), American sycamore, pin oak (Q. palustris), black tupelo (Nyssa sylvatica), and cottonwood (Populus deltoides); in New England, yellow birch, black tupelo, and American sycamore; in the North, tamarack (Larix laricina) and black spruce (Picea mariana); and in New York, white ash (Fraxinus americana), slippery and rock elms (Ulmus rubra and U. thomasii), yellow birch, black tupelo, American sycamore, eastern hemlock (Tsuga canadensis), bur oak (Quercus macrocarpa), swamp white oak, and silver maple. In the silver maple-American elm type, the common associates are water hickory (Carya aquatica), willow oak (Quercus phellos), cedar elm (Ulmus crassifolia), overcup oak (Quercus lyrata), pecan, water oak (Q. nigra), Nuttall oak, (Q. nuttallii), winged elm (Ulmus alata), black tupelo, persimmon (Diospyros virginiana), honeylocust (Gleditsia triacanthos), red maple, boxelder (Acer negundo), and hackberry (Celtis occidentalis). In the sycamore-pecan-American elm type, the common associates are: green ash, sugarberry, hackberry, silver maple, cottonwood, willows (Salix spp.), water oak, Nuttall oak, sweetgum (Liquidambar styraciflua), and river birch (Betula nigra).

The ground cover, both herbaceous and woody plants, is equally varied, changing from north to south and by sites. The geographical range of American elm is so wide and the sites are so varied that none of the ground cover plants can be considered as indicator species.

The 26 cover types of which American elm is a component provide food and cover for a wide variety of mammals and birds. However, none of these animals occur constantly or exclusively with American elm. Those animals that directly affect seed production, survival, or development of this species are discussed in the following sections.

## LIFE HISTORY

### Seeding Habits

The time of flowering, seed ripening, and seed fall varies by about 100 days between the gulf coast and Canada.[6/] The flower buds swell early in February in the South and as late as May in Canada. The trees are in flower 2 to 3 weeks before the leaves unfold. The fruit

---

6/ Unpublished information supplied by D. B. Lawrence, Botany Department, University of Minnesota.

is a samara, ripening as the leaves unfold or soon afterward--late February in the South and June in the North. The seed is dispersed as it ripens, and seed fall is usually complete by the middle of March in the South and by the middle of June in the North. (45)

The flowers are perfect and are borne in dense clusters in 3 or 4 stalked fascicles. American elm is wind-pollinated and the flowers are largely self sterile. One test in Canada showed only 1.5 percent viable seed from self-pollinated flowers and 27.7 percent viable seed from open-pollinated flowers (23). Pollination may be hampered in a wet spring since the anthers will not open in a saturated atmosphere.6/

Seed production may begin in sapling trees 15 years old, but fruiting is seldom abundant before the 40th year when the trees are approaching sawtimber size. Seed production remains high until age 150 years and the maximum seed producing age recorded is 300 years (45). In closed stands, seed production is heaviest in the exposed tops of dominant trees. No data are available as to the amount of seed produced per tree or per acre. The winged seed are light and are readily disseminated by the wind. The bulk of the seed falls within 100 yards of the trees, but some may be carried a quarter of a mile or more. In river bottom stands, the seed may be water borne for greater distances. Commercially cleaned but not dewinged seed averages about 68,000 per pound (range 48,000 to 95,000) with a soundness of 96 percent. Dewinged seed may run up to 164,000 per pound (45).

A number of factors may reduce the seed crop of American elm. Spring frosts can injure and kill both flowers and fruit. Observations in Minnesota showed that, while nearly ripe fruits were not injured by night temperatures of 27° F. for several nights in a row, most of the fruits were killed by frost a week later when night temperatures dropped to 19° and remained below freezing for 60 hours (9). The flower buds, flowers, and fruit are eaten by gray squirrels (Sciurus carolinensis) (40). Elm seed is eaten by both mammals and birds; stomach records include mice, squirrels (Sciurus spp), and opossum (Didelphis marsupialis) among the mammals and ruffed grouse (Bonasa umbellus), bob white (Colinus virginianus), and Hungarian partridges (Perdix perdix) among the birds (46).

## Vegetative Reproduction

American elm will reproduce fairly vigorously by stump sprouts from small trees (13). Large trees 150 to 200 years old seldom sprout vigorously after cutting, although it has been observed in Minnesota that

---

6/ Unpublished information supplied by D. B. Lawrence, Botany Department, University of Minnesota.

almost all replacement in dense undisturbed bottomland stands may be by suckers from the roots of mature trees.[6/] This species can be propagated by cuttings but the results may be quite variable. In one report, cuttings taken in June were rooted with 94-percent success after treatment with indolebutyric acid but rooted poorly with no treatment (12). Actually individual trees may vary widely in respect to the rooting ability of cuttings. Material taken from some trees roots quite readily, especially if juvenile, whereas material from others is very difficult to root, or fails to root at all, regardless of treatment. Tests made in Ohio showed that dormant root cuttings, which root satisfactorily for some species of elm, are not satisfactory for American elm. In trials using 1,000 cuttings, only 8 percent rooted (7). Further trials with softwood cuttings showed that the variation of rooting difficulty was more pronounced in phloem necrosis-resistant stock than with nonresistant stock. In these trials cuttings taken from greenhouse-grown stock were more successful than those taken from field-grown stock. In some tests with indolebutyric acid, the treated cuttings did not root any better than the untreated controls. These tests also demonstrated that leaf bud cuttings were superior to softwood cuttings in propagating American elm.

## Seedling Development

American elm seed generally germinates soon after it is disseminated, although some seed may remain dormant until the following spring (35). This dormancy may be due to conditions within the embryo and can be overcome by stratification in sand for 60 days at 41° F. (45). While germination may extend over a period of 60 days, the bulk of the seed germinates in 6 to 12 days. The seeds germinate best with night temperatures of 68° and day temperatures of 86°. However, germination is almost as good with daily temperatures varying between 50° and 70°. The seed can germinate in darkness, but germination is improved by light (26). The germinative capacity of the seed ranges from 3 to 94 percent (average about 63 percent). American elm seed has been stored in sealed jars at 40° for over 2 years with no loss of germinability.

The seed germinates best on exposed mineral soil, but seedlings can and do become established on moist litter, moss, and decayed logs and stumps. Elm seedlings can grow in full sunlight but make their best height growth with about one-third of full sunlight during the first year (27). After the first year or so, the best height growth comes in full light. Seedling growth is favored by adequate moisture but will be stunted in saturated soils. The stunted seedlings are characterized by early yellowing and loss of the cotyledons, extremely short

---

6/ Unpublished information supplied by D. B. Lawrence, Botany Department, University of Minnesota.

internodes, and small leaf size (28). The seedlings do recover as the soil dries but at a slower rate than do associated red maple seedlings.

The silvicultural practices that favor regeneration of American elm vary somewhat with the species composition of the cover types. The sugarberry-American elm-green ash cover type often follows very heavy or persistant cutting or fire in the sweetgum-Nuttall oak-willow oak types. On upland sites in the North where American elm may be an associate species in the sugar maple-beech-yellow birch type, the elm is favored by heavy cuttings that tend to leave large elms in the stand to reseed openings left by the removal of the other species. In the cottonwood type, elm is often present in the understory. While removal of the cottonwood will favor the growth of elm, cutting is not necessary for elm to succeed cottonwood. In general, elm is favored by heavy cuts whenever sawtimber-size elms are left as the main seed source in the residual stand.

Seedling establishment and growth are generally best on moist but well drained mineral soils and with full sunlight after the first year or so. Elm seedlings can withstand flooding in the dormant season but will die if the flooding is prolonged into the growing season (32). The seedlings may be killed by sudden frosts, but those that survive are soon hardened off in the fall by temperatures alternating between 32° and 50° F. (49). A constant temperature of 32° for 5 days will also harden elm seedlings enough to avoid frost killing (18).

Animal damage is seldom a major problem with American elm and, while browsed by deer (Odocoileus virginianus), rabbits, and hares, it is not generally considered a preferred browse species. One exception may be in prairie plantings where American elm is a preferred food of both white-tailed jack rabbits (Lepus townsendii) and cottontails (Sylvilagus floridanus).7/

While seedlings may be damaged by rabbits and hares, girdled by mice, or have the bark stripped off by squirrels, the losses are seldom extensive enough to prevent regeneration.

Young seedlings are susceptible to damping off, powdery mildew (Uncinula macrospora), and a leaf disease fungus (Gnomonia ulmea), but these are usually not considered as serious problems except in forest nurseries (4, 6, 22). While the Dutch elm disease has been reported on young seedlings, it is not generally considered a problem of seedling-sized elm (14).

---

7/ Personal communication from John J. Zaylskie, Extension Forester, North Dakota.

## Sapling Stage to Maturity

### Growth and Development

In dense forest stands, American elm may develop a clear bole 50 or 60 feet in length before branching. Open-grown trees usually fork near the ground into several erect limbs and develop a wide arching crown (see cover picture). The maximum diameters reported for American elm of 6 to 11 feet are probably for open-grown specimens (16, 17). For forest-grown trees, diameters of 4 to 4½ feet and heights of 100 to 120 feet have been reported in the Lake States.[8/] Elm is a relatively long-lived tree; it matures at about 150 years, and often lives for 175 to 200 years. Since the maximum seed-bearing age reported is 300 years, some individuals evidently reach ages in excess of 300 years. (13, 17, 45)

The root system of American elm is quite plastic, the depth of rooting varying somewhat with soil texture and soil moisture. In heavy, wet soils the root system is widespread, with most of the roots within 3 or 4 feet of the surface. On drier, medium-textured soils the roots usually penetrate 5 to 10 feet. In deep, relatively dry sands in the Dakotas, American elm may develop a taproot reaching down 18 to 20 feet to the water table (19).

Since American elm seldom grows in pure stands, there is little information available for elm yields. On good sites, fully stocked bottomland hardwood stands often yield 10 to 12 thousand board-feet at age 100 and well over 20 thousand board-feet at age 200 years. On poor sites, the yields may be less than half these amounts. Dominant elm may reach heights of over 100 feet on good sites, heights of 80 feet are common on medium sites, but on poor sites on very wet soils or on the dry soils of the plains elm is often only 40 to 60 feet tall at maturity (19).[8/]

### Reaction to Competition

American elm is classed as intermediate in tolerance among the eastern hardwoods (3). It usually responds well to release, often exhibiting better growth at advanced ages than do its associates. Once it becomes dominant in a mixed hardwood stand, it is seldom overtaken by the other species. It can persist for years as an intermediate, but

---

8/ Unpublished information, Lake States Forest Experiment Station.

will pass out of the stand if suppressed by tolerant hardwoods such as sugar maple (Acer saccharum) or beech (Fagus grandifolia). It can, however, persist as an understory under pioneer species such as cottonwood, willow, and aspen. Since elm is intermediate in tolerance, on upland sites it will give way to sugar maple and beech unless favored by heavy cuttings that may permit elm seedlings to become established (13). On wetter sites in the black ash-American elm-red maple type, it is a climax species (31, 38). In the Central Forest the silver maple-American elm type is subclimax and often follows cottonwood and willow and in turn is followed by the sweetgum-Nuttall oak-willow type. The sugarberry-American elm-green ash type is a temporary type following fire or cutting. Although elm may not always be one of the key species in the climax types on these moist sites, it is usually one of the associate species. Generally American elm can be considered a climax species on bottomland sites over most of its range.

## Limiting Factors

Although the native elms are hardy, American elm races from the southern States will not survive the winters in Minnesota.9/ Elm does not frost-crack easily but may sunscald when exposed by heavy cuttings.

The species is reasonably drought resistant, but a prolonged drought period will reduce growth and cause mortality. In the drought of 1934 in the prairie region of the Midwest, losses of American elm and associated species ran as high as 80 to 90 percent (2). The drought of 1951-1954 also caused severe losses in the bottomlands of the South, where American elm appeared to be more susceptible to drought than the water red oaks. Prolonged floods in the spring may cause death or loss of growth. In Minnesota bottomlands, root tip elongation does not begin until the spring floods have receded and soil aeration has increased even if temperature conditions are suitable. On these sites, and often where planted between street and sidewalk, buttress roots are produced as a response to inadequate soil aeration.9/

American elm's tendency towards forking and development of a widespread crown when open grown makes it liable to injury by heavy wet snows and glaze storms. An exceptionally severe ice storm in Illinois in 1937 damaged a number of shade and park trees. Of 37 species examined, American elm ranked fourth in its susceptibility to breakage due to ice accumulation. Of 111 elm trees examined, 84 percent were badly broken, 10 percent had moderate damage and the remaining 6 percent had little injury (11). In dense stands, these injuries are less severe

---

9/ Unpublished information supplied by D. B. Lawrence, Botany Department, University of Minnesota.

and are not generally a management problem. While elm is shallow rooted on wet soils, the wide spread of the roots makes it fairly windfirm (13).

Although fire is injurious when it does occur, fire damage is not a major problem in management of elm stands in the North. In the bottomlands of the South, however, fires during dry falls and sometimes in early spring are extremely damaging. The fires will kill trees up to sapling size and will wound larger trees, admitting heartrots that will progress up the stem.

Animal damage to elm from sapling size to maturity is not serious except for sapsucker (Sphyrapicus varius) damage that degrades the wood (32).

American elm is attacked by a long list of defoliators, bark beetles, borers, and sucking insects, but the economic losses are generally considered to be more serious in shade and park trees than in forest stands (10, 20, 21, 43, 44). Some of the more important insect pests are listed in the following section.

The smaller European bark beetle (Scolytus multistriatus) and the native elm bark beetle (Hylurgopinus rufipes) tunnel into the bark and are the vectors for the Dutch elm disease in the United States. The carpenterworm (Prionoxystus robiniae) burrows into the sapwood and degrades the wood. Among the insects that defoliate elm are the fall cankerworm (Alsophila pometaria), the spring cankerworm (Paleacrita vernata), the forest tent caterpillar (Malacosoma disstria), the elm leaf beetle (Galerucella xanthomelaena), the white marked tussock moth (Hemerocampa leucostigma), and many other leaf-eating insects that attack elm and other hardwoods. The elm cockscomb gall aphid (Colopha ulmicola) forms galls on the leaves but does little damage to the tree. Several scale insects attack elm and may cause damage. Both the elm scurfy scale (Chionaspis americana) and the European elm scale (Gossyparia spuria) are widely distributed. Among the leafhoppers, the elm leafhopper (Scaphoideus luteolus) must be classed as a serious pest since it is the vector for phloem necrosis (44).

Control measures for the insect enemies of elm are usually confined to shade and park trees and are seldom used in forest stands. However, the forest stands do maintain considerable populations that weaken the trees and serve as vectors for diseases.

American elm is attacked by a variety of wilts, cankers, mildews, wood rots, slime fluxes, and virus diseases. About 120 diseases of this species have been reported (4, 6, 22, 29). The two most important are the Dutch elm disease caused by a wilt fungus (Ceratocystis ulmi) and phloem necrosis caused by a virus (Morsus ulmi). These two, like most elm diseases, are primarily a problem in shade and park trees although

the Dutch elm disease is considered serious in forest stands in the older infected areas, particularly in New Jersey. Among the common diseases are the Verticillium wilt (Verticillium albo-atrum), the die-back caused by another wilt (Dothiorella ulmi), the leaf disease caused by black spot (Gnomonia ulmea), the twig blights caused by Coniothyrum spp. and Vermicularia spp., the cankers caused by Nectria spp. and Phytophthora inflata, the slime flux caused by the bacterium (Erwinia nimipressuralis) and the virus diseases, elm mosaic, and Zonate canker that are of minor importance compared to phloem necrosis. Some of the common wood rot fungi are Pleurotus ulmarius, P. ostreatus, Armillaria mellea, Fomes applanatus, F. igniarius, numerous species of Polyporus, and occasionally Hydnum septentrionale. While these fungi cause considerable wood losses in older timber, in young sawtimber the losses from sweep and crook may exceed the loss from decay.

## SPECIAL FEATURES

American elm has no special anatomical characteristics that are not shared by at least one other species of elm. The sectioned outer bark of both American and rock elms shows irregular, corky, buff-colored patches interspersed with the reddish-brown fibrous tissues. Most elms develop a widespread crown when open grown, but the other native species seldom develop the vase or umbrella-shaped crown that is characteristic of American elm.

The wood of American elm, along with that of the other native elms, is used principally in the manufacture of containers (boxes, baskets, crates, cheese boxes, and slack barrels) and furniture; dairy, poultry, and apiary supplies; caskets and burial boxes; and vehicle parts (5).

American elms are killed back by foliage sprays of ammonium sulfamate and 2,4-D or 2,4,5-T esters alone or in combination, by basal sprays of the combined 2,4-D and 2,4,5-T esters in oil, and by 2,4,5-T in oil applied to girdles or frills in the trunk (36).

American elm probably is the most widely used species in the United States for shade and street tree planting.

## RACES, HYBRIDS, AND OTHER GENETIC FEATURES

Most of the genetics research of elms has been concerned with the resistance of various species, varieties, races, and hybrids to Dutch elm disease or to phloem necrosis. Natural hybridization in American

elm is rather uncommon, although controlled crosses have been made with the Siberian elm (Ulmus pumila) and with U. pedunculata (34). The success of controlled crosses is often quite poor. From about 20,000 controlled American-Siberian elm crosses, fewer than 100 seed were obtained and only a fraction of these germinated. Of the hybrids obtained, one has resisted repeated inoculations with the Dutch elm disease fungus (43). Natural hybrids between American and Siberian elms have been found in Minnesota.10/ Normal vegetative cells of most elms have 14 pairs (28) of chromosomes but those of American elm have 28 pairs (56). American elm, therefore, is a natural tetraploid. (37)

Florida elm (U. americana var. floridana) is the only forest variety recognized (24). The lack of winter hardiness of elm from the southern States, when planted in Minnesota, indicates that geographical races have developed. Certain regional races of American elm are resistant to both high and low temperatures, as evidenced by its occurrence in the northern plains where summer temperatures may reach 110° F. and winter temperatures may drop to -50°.11/

A few horticultural forms have been recognized by some authors. These are: U. a. columnaris, a form with upright branches; U. a. ascendens, a form with a narrow columnar head; and U. a. pendula, a variety with long pendulous branches (33). Fernald also recognized four forms based upon leaf and twig differences (15). These differences are based on whether the upper surface of the leaf is smooth or scabrous and whether the twigs are glabrous or pubescent. According to Fernald, these four forms are widely distributed throughout the range of American elm.

---

10/ Unpublished information supplied by D. P. Duncan, School of Forestry, University of Minnesota.

11/ Unpublished information supplied by D. B. Lawrence, Botany Department, University of Minnesota.

## LITERATURE CITED


1. Aikman, J. M.
   1935. Native vegetation of the region. In Possibilities of Shelterbelt Planting in the Plains Region. U. S. Forest Serv. Spec. Rpt., pp. 155-174, illus.

2. Albertson, F. W., and Weaver, J. E.
   1945. Injury and death or recovery of trees in prairie climate. Ecol. Monog. 15: 393-433.

3. Baker, Frederick S.
   1949. A revised tolerance table. Jour. Forestry 47: 179-181.

4. Baxter, Dow Vawter.
   1943. Pathology in forest practice. 618 pp., illus. New York.

5. Betts, H. S.
   1945. American Woods; Elm. U. S. Forest Serv., 10 pp., illus.

6. Boyce, J. S.
   1938. Forest pathology. 600 pp., illus. New York.

7. Bretz, T. W., and Swingle, R. U.
   1950. Propagation of disease resistant elms. Amer. Nurseryman 92: 7-9, 65-66.

8. Brush, W. D.
   1918. Utilization of elm. U. S. Dept. Agr. Bul. 683, 43 pp., illus.

9. Butters, F. K., and Rosendahl, C. O.
   1911. Some effects of severe frost upon vegetation in a condition of active growth. Minn. Bot. Studies 4: 153-159.

10. Craighead, F. C.
    1950. Insect enemies of eastern forests. U. S. Dept. Agr. Misc. Pub. 657, 679 pp., illus.

11. Croxton, W. C.
    1939. A study of the tolerance of trees to breakage by ice accumulation. Ecol. 20: 71-73.

12. Doran, W. L.
    1941. The propagation of some trees and shrubs by cuttings. Mass. Agr. Expt. Sta. Bul. 382, 56 pp.

13. Eyre, F. H., and Zillgitt, W. M.
1953. Partial cuttings in northern hardwoods of the Lake States. U. S. Dept. Agr. Tech. Bul. 1076, 124 pp., illus.

14. Feldman, A. W., and Caroselli, N. E.
1951. Dutch elm disease in young seedlings. Phytopath. 41: 47-51.

15. Fernald, M. L.
1945. The indigenous variations of Ulmus americana. Rhodora 47: 93-142.

16. _____.
1950. Gray's manual of botany. Ed. 8, 1632 pp., illus. New York.

17. Harlow, William M., and Harrar, Elwood S.
1950. Textbook of dendrology. Ed. 3, 555 pp., illus. New York.

18. Harvey, R. B.
1930. Length of exposure to low temperatures as a factor in the hardening process in tree seedlings. Jour. Forestry 28: 50-54.

19. Hayes, F. H., and Stoeckeler, J. H.
1935. Soil and forest relationships of the shelterbelt zone. In Possibilities of Shelterbelt Planting in the Plains Region. U. S Dept. Agr. Spec. Rpt., pp. 111-153, illus.

20. Hoffman, C. H.
1940. Additions to annotated lists of insects reared from elm bark and wood. Bul. Brooklyn Ent. Soc. 35: 54-63.

21. _____.
1942. Annotated list of elm insects of the United States. U. S. Dept. Agr. Misc. Pub. 466, 20 pp.

22. Hubert, Ernest E.
1931. An outline of forest pathology. 543 pp., illus. New York.

23. Johnson, L. P. V.
1946. Fertilization in Ulmus with special reference to hybridization procedure. Canad. Jour. Res., Sec. C., Bot. Sci. 24: 1-3.

24. Little, Elbert L.
1953. Check list of native and naturalized trees of the United States (including Alaska). U. S. Dept. Agr. Handb. 41, 472 pp.

25. Lutz, Harold J., and Chandler, Robert F., Jr.
1946. Forest soils. 514 pp., illus. New York and London.

26. McDermott, R. E.
1953. Light as a factor in the germination of some bottomland hardwood seeds. Jour. Forestry 51: 203-204.

27. _____.
1954. Seedling tolerance as a factor in bottomland timber succession. Mo. Agr. Expt. Sta. Res. Bul. 557, 10 pp.

28. _____.
1954. Effects of saturated soil on seedling growth. Ecol. 35: 36-41.

29. Marshall, Rush P., and Waterman, Alma M.
1948. Common diseases of important shade trees. U. S. Dept. Agr. Farmers' Bul. 1987, 53 pp., illus.

30. Munns, E. N.
1938. The distribution of important forest trees of the United States. U. S. Dept. Agr. Misc. Pub. 297, 176 pp.

31. Oosting, H. J.
1942. An ecological analysis of the plant communities of Piedmont, North Carolina. Amer. Mid. Nat. 28: 56-76.

32. Putnam, J. A.
1951. Management of bottomland hardwoods. U. S. Forest Serv., Southern Forest Expt. Sta. Occas. Paper 116, 60 pp. (Processed.)

33. Rehder, Alfred.
1940. Manual of cultivated trees and shrubs. 2nd ed., Rev., 996 pp. New York.

34. Richens, R. H.
1945. Forest tree breeding and genetics. Imp. Agr. Bur. Joint Pub. 8, 79 pp.

35. Rudolf, Paul O.
1937. Delayed germination in American elm. Jour. Forestry 35: 876-877.

36. _____, and Watt, Richard F.
1956. Chemical control of brush and trees in the Lake States. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 41, 58 pp., illus. (Processed.)

37. Sax, K.
1933. Chromosome numbers in Ulmus and related genera. Jour. Arnold Arboretum 14: 82-84, illus.

38. Society of American Foresters.
1954. Forest cover types of North America (exclusive of Mexico). Rpt. of Com. on Forest Types, 67 pp., illus. Washington, D. C.

39. Sudworth, G. B.
1927. Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Agr. Misc. Cir. 92, 295 pp.

40. Torres, J. K.
1939. Gray squirrel utilization of elm. Jour. Wildlife Mangt. 3: 358-359.

41. U. S. Department of Agriculture.
1938. Soils and man. U. S. Dept. Agr. Yearbook, 1232 pp., illus.

42. _____.
1941. Climate and man. U. S. Dept. Agr. Yearbook, 1248 pp., illus.

43. _____.
1949. Trees. U. S. Dept. Agr. Yearbook, 944 pp., illus.

44. _____.
1952. Insects. U. S. Dept. Agr. Yearbook, 780 pp., illus.

45. U. S. Forest Service.
1948. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

46. Van Dersal, William R.
1938. Native woody plants of the United States: Their erosion-control and wildlife values. U. S. Dept. Agr. Misc. Pub. 303, 362 pp., illus.

47. Westveld, R. H.
1933. The relation of certain soil characteristics to forest growth and composition in the northern hardwood forest of northern Michigan. Mich. Agr. Expt. Sta. Tech. Bul. 135, 51 pp.

48. Wilde, S. A.
1946. Forest soils and forest growth. 241 pp., illus.
Waltham, Mass.

49. Wilmer, J.
1952. A study of desiccation in relation to winter injury.
Sci. Agr. 32: 651-658.

## SILVICAL REPORTS PUBLISHED OR IN PREPARATION

This is the seventh of the silvical reports being prepared by the Lake States Forest Experiment Station. Already published are:

Station Paper 44 - Red pine

Station Paper 45 - Black spruce

Station Paper 47 - Rock elm

Station Paper 49 - Quaking aspen

Station Paper 50 - Sugar maple

Station Paper 52 - Tamarack

Ensuing reports will cover the following species:

| | |
|---|---|
| Bigtooth aspen | Jack pine |
| Basswood | Balsam poplar |
| Slippery elm | White spruce |
| Black maple | Northern white-cedar |

SOME RECENT STATION PAPERS

Publications of the Lake States Forest Experiment Station.
L. P. Olsen and H. A. Woodworth.
Station Paper 39, 130 pp. 1956.

Guide for Selecting Superior Forest Trees and Stands in the Lake States.
Paul O. Rudolf.
Station Paper 40, 32 pp., illus. 1956.

Chemical Control of Brush and Trees in the Lake States.
Paul O. Rudolf and Richard F. Watt.
Station Paper 41, 58 pp., illus. 1956.

The Forest Insect and Disease Situation, Lake States, 1956.
L. C. Beckwith and R. L. Anderson.
Station Paper 42, 26 pp., illus. 1956.

Wood Pallets in the Minneapolis-St. Paul Area: An Outlet for Low-Grade Hardwoods.
John R. Warner and D. R. Cowan.
Station Paper 43, 34 pp., illus. 1956.

The Market for Domestic Charcoal in Wisconsin.
John R. Warner and William B. Lord.
Station Paper 46, 15 pp., illus. 1957.

Natural Regeneration on a 2-Acre Mixed-Oak Clear Cutting Five Years After Logging.
Harold F. Scholz and A. J. DeVriend.
Station Paper 48, 11 pp., illus. 1957.

Deterioration of Sugar Maple Following Logging Damage.
Gene A. Hesterberg.
Station Paper 51, 58 pp., illus. 1957.

A Record of the Timber Cut from Forests of the Lake States, 1954.
Arthur G. Horn.
Station Paper 53, 47 pp., illus. 1957.